Play in fishes, frogs and reptiles

Gordon M. Burghardt

What animals engage in play? Not too many years ago play was considered by most scholars and scientists as something we see in rather intelligent warm-blooded animals, such as monkeys and apes, dogs, cats, elephants, otters, bears, and some birds, such as crows and parrots. Of course, horses play, especially young ones: the origins of the phrase 'horsing around' are not hard to fathom. In fact, many other mammals play, including marsupials such as wombats and kangaroos. Indeed, the play behavior of no animal has been studied as much as that of the laboratory rat: Serge and Vivien Pellis wrote a book largely devoted to reviewing some of the literature on rat play. But what about animals other than warm-blooded vertebrates? Do they play and, if so, how do we know? To answer this we need to clear up some neglected business.

What is play and how do we recognize it? While many definitions of play have been proposed, none has worked well; behavior has therefore been labeled as play largely on anthropomorphic grounds, so that people applied to animals a largely human-derived view of play as non-serious fun. Termed anthropocentrism, this may work well enough with puppies and kittens, animals we know well, where we recognize signs of pleasure and lack of seriousness that often are integral to definitions of play. A definition should actually help to identify play in species or contexts in which we do not already accept that play is being performed. We also need a definition or set of criteria that apply to all the major types of animal play: social play, play with objects, and solitary locomotor play — gamboling, twisting, leaping, and swinging. All these types of play can occur on land, in the air, and in the water.

A set of five minimal criteria that helps identify play of any type in any animal has been generally adopted (Graham and Burghardt, 2010). The five criteria are that the behavior should: (1) be incompletely functional in the context in which it appears; (2) be spontaneous, pleasurable, rewarding, or voluntary; (3) be different from other more serious behaviors in form (for example, be exaggerated) or timing (for example, occur early in life, before the more serious version is needed); (4) be repeated, but not in abnormal and unvarying stereotypic form (for example, rocking or pacing); and (5) be initiated in the absence of severe stress. In a single sentence: *play is repeated, seemingly non-functional behavior differing from more adaptive versions structurally, contextually, or developmentally, and initiated when the animal is in a relaxed, unstimulating, or low stress setting* (Burghardt, 2014).

Applying these criteria allows us to determine if a possible example of animal behavior satisfies all the criteria or just some of them, pointing to others that we need to investigate and apply. But even when the five criteria are met, this only sets the stage for further analysis. Just labeling a behavior as play does not identify the brain and behavior mechanisms underlying it, the adaptive functions, if any, served by the behavior, its evolutionary history, how it develops in individual animals, or how it is experienced by the animals. To answer these questions is often difficult, even in well studied playful species such as rats and monkeys. For now, we first need to identify play wherever it may occur in the animal world and retain an open mind. Here are a few contenders for play in the so-called lower vertebrates, largely, though not universally, denied the playful moniker.

What are some examples of play in fish? Whether fish play is a controversy going back to the 19th century. Perhaps the earliest detailed claims were by the naturalist Charles Holder, who described needlefishes leaping over floating sticks and even a turtle. But the bias against fish being let into the pantheon of players prevented locomotor, social, and object play being seriously considered as occurring in them. An influential paper on concepts of play published in 1945 by Frank Beach, perhaps then the leading comparative psychologist in America, debunked such early work so effectively that his seriously flawed arguments, along with the desire of fish behavior researchers to avoid anthropomorphic and anecdotal observations, led those in the field to dismiss the possibility that fish could play. Today the play criteria and readily available video footage has reopened the question.

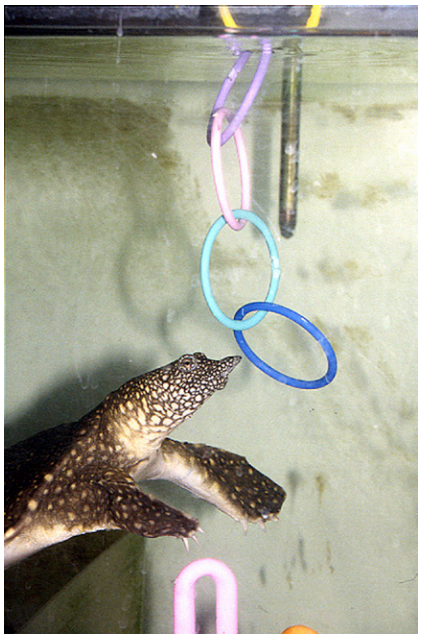

Figure 1. A young Nile soft-shelled turtle interacting with colored rings. (Photo: Gordon M. Burghardt.)

These early observations and many others satisfy all or most of the play criteria. Thus, leapfrogging in fish fits, as does the balancing of twigs and batting of balls in mormyrid fish species, stingrays batting around balls and competing for the opportunity to do so, and cichlid fish that repeatedly strike a self-righting thermometer. While the incidence and complexity of play is low as compared to mammals, fishes provide good tests of play criteria.

Are there any examples of play in frogs? Unlike in fish, play in amphibians has been very rarely considered in discussions of their behavior. To date there are still no claims for, or observations of, play in salamanders or caecilians, two major groups of amphibians. In frogs, there are some tantalizing examples. For instance, dendrobatid (dart poison) frogs are diurnal and active species whose toxicity seems to encourage more conspicuous and active behavior. They are also quite social. Adults often engage in brief wrestling

bouts irrespective of sex. This behavior seems to fit the play criteria and certainly warrants closer study. I have studied Vietnamese mossy frog tadpoles repeatedly 'riding' bubbles from an airstone at the bottom of a tall tank to the top. I have observed similar behavior in marine fish in a large very tall communal aquarium with such an air column. Here it is actually possible to be a bit anthropomorphic as the behavior does look as if it would be fun for us!

What about play in reptiles? Convincing examples of play have been found in lizards, turtles, and crocodilians. Komodo dragons, the world's largest lizards, engage in complex interactions with objects such as buckets, boxes, old shoes, and balls. In fact, sped up a little bit on video, their behavior is similar to that of dogs. They even play tug of war with their keepers over objects such as cans and handkerchiefs. Aquatic Nile soft-shelled turtles will bounce basketballs and floating bottles back and forth, manipulate hoops (Figure 1) and play tug of war with their keepers using hoses. North American Emydid pond turtles often engage in foreclaw titillation displays in social interactions with each other as hatchlings, behavior that otherwise is only found in sexual and sometimes agonistic encounters as adults. Crocodilians also engage in object play. A giant saltwater crocodile played with a basketball on a tether as part of enrichment. Although only a few papers have been published and cited in the references below, behavior patterns meeting the play criteria have been met.

If play is so widespread in the animal kingdom, how and why did this happen? Play is often found in the most intelligent and adaptable species, but we now know that it is not restricted to them. The presence of play facilitates novel and creative behavior, but this does not tell us about its origins. Indeed, play is so diverse and heterogeneous that no single factor can explain when and where it appears in the lives of animals. We also know little about the function of play in these animals, but as we are just beginning to get a handle on the function of play in mammals, our relative ignorance about fish, frogs, and reptiles is not surprising. But invertebrates play also — in fact, some of the best evidence for the function of play comes from work on spiders, where play was never observed until recently.

So, play, while very prominent in mammals and many birds, is relatively rare in other species. One proposal, termed Surplus Resource Theory, is that the origins of play are found in animals with sufficient metabolic resources for sustained activity and complex behavior that needs to be deployed in varying ways. They also need the time and safety to engage in behavior that may not be immediately advantageous, but through which animals learn or perfect behavioral skills, social acumen, physiological or perceptual abilities, and other means that enhance survival compared to non-playing conspecifics. On the other hand, in its ancient and more primitive incarnations, playing may not have had any specific advantage over non-playing, but eventually the benefits outweighed the often serious costs of play in energy and risks of injury and predation. A door has been opened, and exploring what lies beyond may be both fascinating and important.

Where can I find out more about play?

Bateson, P., and Martin, P. (2013). Play, playfulness, creativity, and innovation. (Cambridge, UK: Cambridge University Press.)

Beach, F.A. (1945). Current concepts of play in animals. Am. Nat. *79*, 523–541.

Bekoff, M., and Byers, J.A. (Eds.). (1998). Animal Play: Evolutionary, Comparative, and Ecological Perspectives. (Cambridge, UK: Cambridge University Press.)

Burghardt, G.M. (2005). The Genesis of Animal Play: Testing the Limits. (Cambridge, MA: MIT Press.)

Burghardt, G.M. (2011). Defining and recognizing play. In The Oxford Handbook of the Development of Play, A.D. Pellegrini (Ed.) (New York: Oxford University Press.) pp. 9–18.

Burghardt, G.M. (2014). A brief glimpse at the long evolutionary history of play. Anim. Behav. Cogn. *1*, 90–98.

Burghardt, G.M., Dinets, V., and Murphy, J.B. (2014). Highly repetitive object play in a cichlid fish (*Tropheus duboisi*). Ethology *120*, http://dx.doi.org/10.1111/eth.12312.

Graham, K.L., and Burghardt, G.M. (2010). Current perspectives on the biological study of play: Signs of progress. Q. Rev. Biol. *85*, 393–418.

Pellis, S.M., and Pellis, V.C. (2009). The Playful Brain, Venturing to the Limits of Neuroscience. (Oxford, UK: Oneworld Press.)

Pruitt, J.N., Burghardt, G.M., and Riechert, S.E. (2012). Non-conceptive sexual behavior in spiders: a form of play associated with body condition, personality type, and male intrasexual selection. Ethology *118*, 33–40.

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Fun and play in invertebrates

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Where should we look for playful invertebrates? The notion that invertebrates might indulge in play, and especially that they might have fun doing it, is generally met with scepticism. But given that the same was true of play in 'lower' vertebrates such as reptiles and fish until relatively recently, perhaps we shouldn't discount the possibility outright. So where should we look? Given that play is most frequently observed in large-brained vertebrate lineages, perhaps our first port of call should be the cephalopods. These large-brained molluscs are heralded as uniquely intelligent amongst the invertebrates, and their deep evolutionary split from the vertebrates provides us with a unique independent data point against which to investigate general trends in intelligence, cognition and, in this case, play. Shallow water coleoid cephalopods — octopuses, cuttlefish and squid — are well known for their capacity for complex learning and their flexible, complex behaviours. Their brains are comparable to vertebrates in relative size, with dedicated learning and memory centres analogous in many ways to the vertebrate cortex. On the flip side, cephalopods don't afford parental care to their offspring, are typically short lived (often one or two years), and are often semelparous (that is, they die after their first attempt at reproduction). Furthermore, the species considered to have the highest cognitive intelligence are solitary and show little or no social behaviour. What evidence is there then that cephalopods play, and more importantly, do they have fun doing it?

So do cephalopods play? When introducing my behavioural experiments with cephalopods in seminars, I often joke that there is nothing more demoralizing than being outsmarted by your experimental animal. Indeed, there are some individuals that seem to delight in being mischievous. For example, some cuttlefish use their siphons to squirt water at their keeper when impatient to be fed. However, there is currently